urban land use in ONTARIO

URBAN LAND USE in ONTARIO

Areas and Intensities

DEPARTMENT OF MUNICIPAL AFFAIRS

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PREFACE

This publication marks the first attempt to analyse urban land use areas in Ontario. Although somewhat similar studies have been published in the United States, the conclusions and their applicability to the Ontario scene are limited because of different socio-economic conditions, age of data and method of analysis.

It is hoped that the report will be helpful to both the professional and the layman involved in the planning process in Ontario.

The major sources of land use data in this study were official plans and local reports. In addition, several municipal planning departments forwarded the required information upon request and their assistance is gratefully acknowledged.

The study was carried out by Mr. D. A. Montgomery, Research Planner, assisted by Mr. R. W. Winnicki, Research Assistant, under the direction of Mr. A. Garfin, Supervisor, Special Studies Section of the Community Planning Branch.

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INTRODUCTION

A common question arises when community planners attempt to forecast future land use needs during background studies to official plans. How much land is absorbed by various uses in other municipalities?

This study attempts to answer that question by examining the quantities of land devoted to different uses in a sample of urban municipalities in the hope that it provides a comparative background against which standards and forecasts may be evaluated by planners.*

The hypothesis underlying this analysis is that *the quantities and population intensities of land in residential, commercial, and industrial uses are closely related to the populations of urban municipalities.* The analysis will confirm or reject this hypothesis and will examine some of the similarities and differences in the sample used.

It must be emphasized that the land use models developed in this study are not intended for use as norms for supplying solutions to each and every situation. Their value lies in permitting comparison

*Similar land use studies in the U.S.A.:

Harland Bartholomew, *Land Uses in American Cities,*
(Cambridge: Harvard University Press, 1955).

J. H. Niedercorn and E. F. R. Hearle,
Recent Land Use Trends in Forty-Eight Large American Cities,
(Rand Corporation, Memorandum RM-3664-FF, June, 1963).

of land use statistics of the 1960's. They can help an urban municipality appraise its present and future land requirements by directing attention to those elements requiring detailed examination and rationalization.

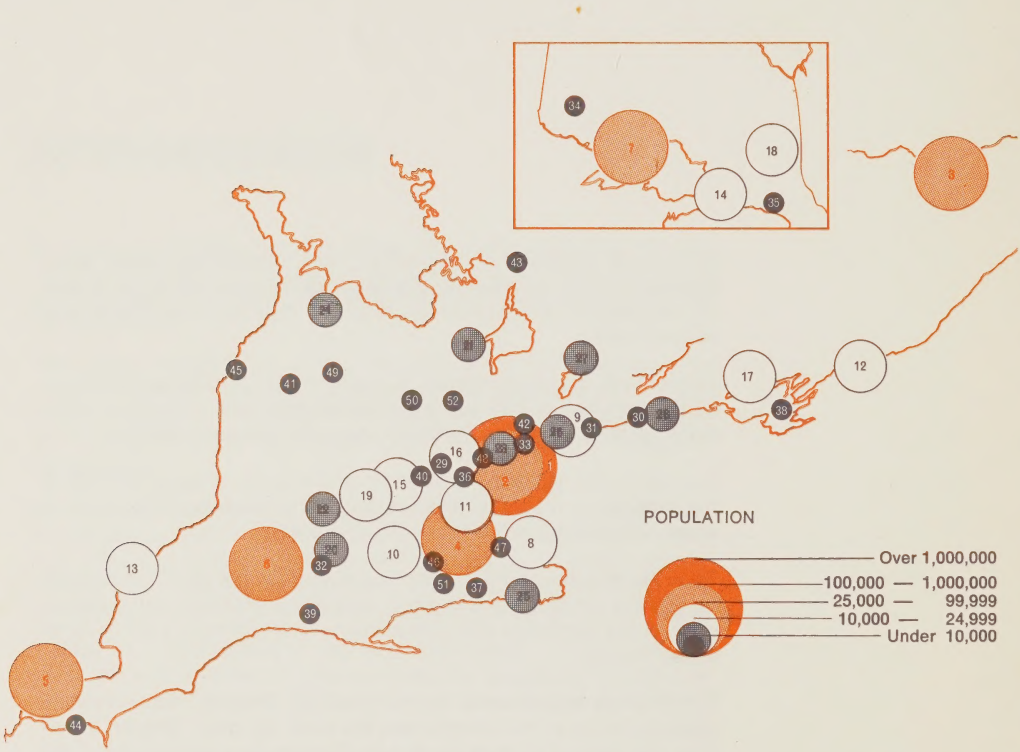
Comparison alone, of course, is not enough. It must be tempered by the knowledge that no two municipalities are completely alike and that land use characteristics vary with local conditions.

Another factor to be considered in applying the study's findings is the probability that past and present forces shaping today's urban areas will change or disappear in the future.

Thus the models and diagrams developed in this study should not be applied indiscriminately. They must be synthesized with a knowledge of the dynamics of a community's development to bring significant results.

The analysis is presented in four sections: Section 1 examines the characteristics of the sample and the land use data; Section 2 outlines the method of analysis; Section 3 presents a description of the relationship of population to the total developed area, and to residential, commercial, and industrial land uses using diagrams and models; Section 4 summarizes the study's conclusions in a simple model which integrates the various relationships.

Figure 1
DISTRIBUTION AND POPULATION SIZE OF URBAN MUNICIPALITIES IN SURVEY



see Appendix for place names

1. LAND USE DATA

THE SAMPLE

Population and land use data were assembled and tabulated for fifty-two cities, towns and villages in Ontario from planning studies and local planning staffs. The sample comprises those urban municipalities in Ontario where land use information was both available and comparable for valid analysis.

Most of the data are based on land use in the 1960's. The populations range from 700 to 1,700,000 persons (see Appendix).

The sample provides a good cross-section. It is generally representative of the geographical distribution of urban municipalities in the province (Figure 1) and of the population distribution of urban municipalities of over 1000 persons.*

All land use data apply to developed areas within municipal boundaries. Developed area is defined in this study to exclude vacant and agricultural land.

The absence of fringe development data outside the boundaries ruled out an analysis based on the entire urban developed area. This feature will likely have little or no effect on the calculated data of most of the municipalities in the sample. Yet it is possible that data for large cities would be affected by growth beyond the municipal boundaries. Thus, an examination of the entire urban developed area would likely reveal that the quantity of residential land would tend to be higher in these cities, and residential density lower than the statistics now describe.

*Medium-sized cities are slightly overrepresented in the sample of fifty-two as compared to the proportion they represent in the universe of 224 urban municipalities in Ontario of over 1000 population (*Census of Canada, 1966*).

LAND USE CLASSIFICATION

1. *Residential*
2. *Commercial*
3. *Industrial* (includes)
   - Manufacturing
   - Warehousing
   - Utilities
   - Railyards
   - Airports
   - Expressways
4. *Total Developed Area* (includes)
   - Residential
   - Commercial
   - Industrial
   - Institutional
   - Parks and Public Open Space

Each of the above four categories was tabulated by:

A. *Area* — in terms of gross acres
B. *Intensity* — in terms of population per gross acre

The data collected for the fifty-two urban municipalities were studied in the context of the quantity of gross acres for each land use and the "population per gross acre" of each use. "Gross acres" includes adjacent streets.

2. METHOD OF ANALYSIS

The relationship of total developed area to population (Figure 2) has been selected here to illustrate the method of analysis and to indicate how an urban municipality may be compared to the information on the diagrams.

GRAPHICAL REGRESSION ANALYSIS

Figure 2 shows the relationship plotted as dots for the urban municipalities. The numbers adjacent to the dots identify the municipalities as listed on page ten (see Appendix for the populations and dates of land use data).

Since the population range of the urban municipalities (700-1,700,000) is too wide to be presented on an arithmetic scale, logarithmic scales are used.

The line drawn through the scatter of observations in Figure 2 is the regression line — the line of equilibrium or "best fit" for this relationship.* This line may be considered to constitute a "model" of the relationship. Although it does not describe the exact quantities of land associated with population as shown by the dots, it follows the general trend of the dots to give a relatively accurate approximation of the relationship of total developed area to population.

EXAMPLE: URBANVILLE

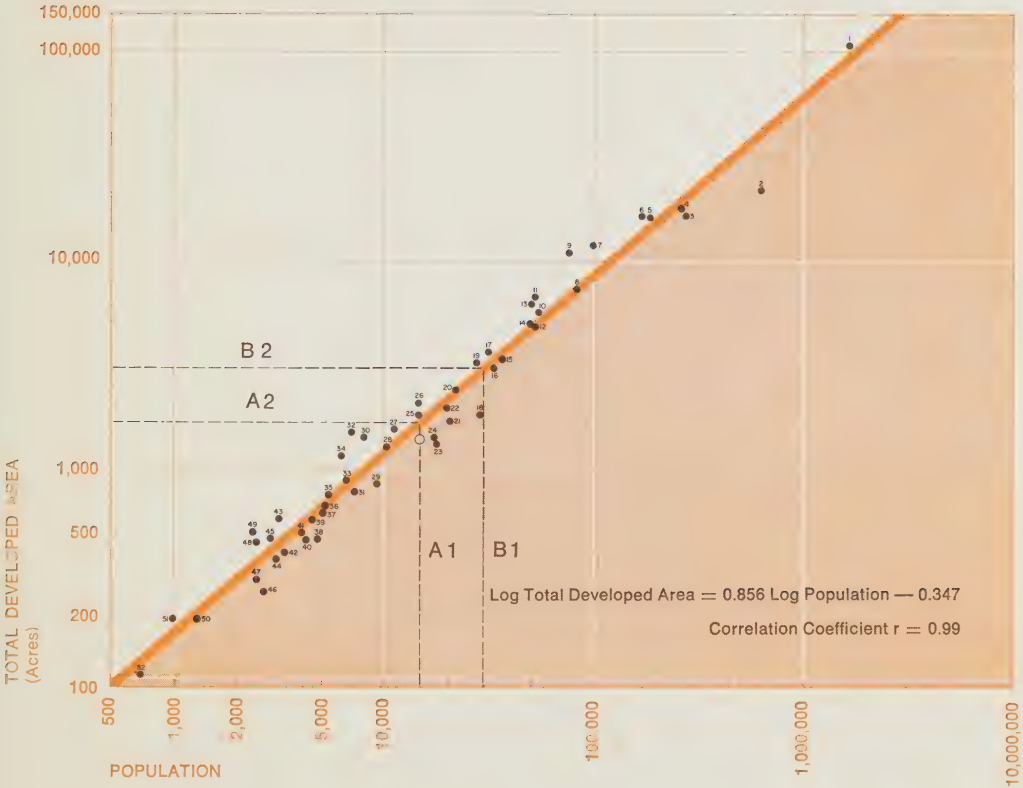
To illustrate the use of the graphical regression analysis, suppose one wishes to compare the quantity of land absorbed by the total

*The line (regression line) was plotted on the diagram using this equation which was derived from regression analysis:
(logarithm of Total Developed Area) = 0.856 times (the logarithm of Population) — 0.347

LIST OF MUNICIPALITIES IN SURVEY

Municipality	Code No.	Municipality	Code No.
Acton	40	*Markham*	33
Aylmer	39	*Metro Toronto*	1
Barrie	21	*Oakville*	11
Beamsville	47	*Oshawa*	9
Belleville	17	*Ottawa*	3
Bowmanville	31	*Owen Sound*	24
Brampton	16	*Picton*	38
Brantford	10	*Port Colborne*	25
Caledonia	46	*Port Hope*	30
Cayuga	51	*Richmond Hill*	23
Cobourg	28	*St. Catharines*	8
Dryden	34	*Sarnia*	13
Dunnville	37	*Sault Ste. Marie*	14
Durham	49	*Shelburne*	50
Espanola	35	*Stouffville*	42
Georgetown	29	*Stratford*	22
Gravenhurst	43	*Streetsville*	36
Guelph	15	*Timmins*	18
Hamilton	4	*Toronto*	2
Ingersoll	32	*Tottenham*	52
Kincardine	45	*Walkerton*	41
Kingston	12	*Waterloo*	19
Kingsville	44	*Whitby*	26
Lakehead	7	*Windsor*	5
Lindsay	27	*Woodbridge*	48
London	6	*Woodstock*	20

Figure 2
Relationship of TOTAL DEVELOPED AREA TO POPULATION
(Logarithmic Scales)



developed area of a hypothetical municipality, Urbanville, with the model and with other cities of the same order of population.

Assume Urbanville has 15,000 people and a total developed area of 1400 acres. A vertical line (A 1) is projected to the regression line from the 15,000 point on the Population axis (as shown in Figure 2). A horizontal line (A 2) is then projected to the Total Developed Area axis from the point where 'A 1' intersects the regression line.

The reading on the Total Developed Area axis indicates a gross acreage of 1600. This is approximately the same value that would be obtained for Urbanville if its population of 15,000 had been inserted in the mathematical form of the model.*

Urbanville can now be compared with the actual quantities of total developed area in the urban municipalities plotted on the diagram that have roughly similar populations. These values range from 1,300 gross acres (no. 23 - Richmond Hill) to 2,000 gross acres (no. 26 - Whitby). Owen Sound and Port Colborne fall between these values. Urbanville's total developed area (1,400 gross acres) is in the lower end of the range of actual values and less than the amount generated by the statistical model.

Suppose Urbanville's population forecast calls for a doubling to 30,000 in the near future. The model generates a value of 3,100 acres of total developed area (B 2) for the forecast population.**

By referring to the group of observations at the 30,000 population level on the diagram, Urbanville's forecast may be placed in the context of the total developed area of municipalities already at that population. These values range from 1,800 (no. 18 - Timmins) to 3,700 (no. 17 - Belleville) gross acres. Timmins is unusually low.

*i.e., Log T.D.A. = 0.856 (Log 15,000) — 0.347
= 3.228
T.D.A. = 1690

**Section 4 outlines the assumptions that are required when forecasting with a comparative static model.

Guelph (no. 15), Brampton (no. 16), and Waterloo (no. 19) all have values similar to Belleville at the upper end of the range.

The same analytic method may be used for each of the land use components dealt with in the next section.

CORRELATION ANALYSIS

From the statistical relationship, a "correlation coefficient" was computed to measure the degree to which the urban municipalities in the scatter diagram diverge from the line. Consequently, it provides a measure of the degree to which the model approximates reality.

The correlation coefficient also provides a tool for measuring the absolute and relative strengths of the relationships without depending solely on a visual examination of scatter diagrams.*

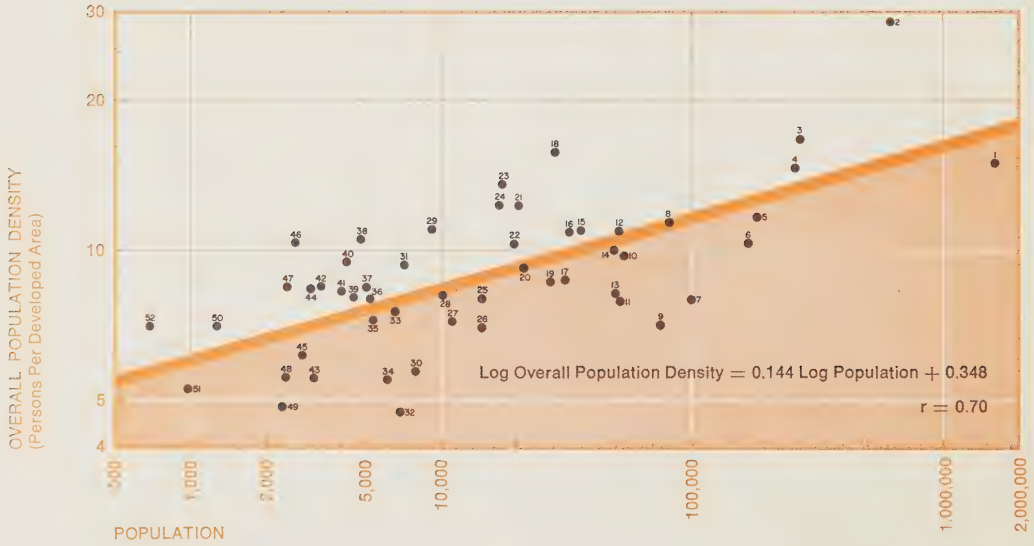
A coefficient was computed for each of the relationships shown in the diagrams (Figures 2 to 9). The relationships range in degree from a high correlation (0.99) for the relationship of total developed area to population (Figure 2), to virtually no correlation (0.14) in the relationship of population per gross industrial acre to overall population (Figure 9).

The lack of correlation in Figure 9 indicates that no regular pattern exists between the size of urban municipalities and industrial intensity. Thus, a straight line model of the relationship would be extremely inaccurate.

*A correlation coefficient of 1.00 indicates a perfect relationship among the data in the diagrams: all the dots lie on the regression line. At the other extreme, a correlation coefficient of 0.00 indicates no relationship: the dots are dispersed and show no tendency to cluster along the regression line.

Figure 3
Relationship of OVERALL POPULATION DENSITY TO POPULATION

(Logarithmic Scales)



3. LAND USE RELATIONSHIPS

The second aspect of total developed area — population per gross acre — is presented in Figure 3. The remaining diagrams show in sequence the relationship of each of the land use categories — residential, commercial and industrial — to population.

Again, these are presented in two ways. They show the number of acres consumed by each use as well as the number of persons per acre for each use.

The main patterns and variations within these patterns can now be briefly examined.

GENERAL PATTERNS

The diagram (Figure 2) showing the relationship of total developed area to population, and the high correlation uncovered by the analysis ($r = 0.99$) supports the contention that the quantity of land consumed by urban municipalities is directly related to their population.

Although the pattern appears as a straight line when plotted on logarithmic graph paper, the regression line actually describes a declining growth curve: as one moves from left to right, from lower to higher populations along the regression line, the total developed area increases, but at a decreasing rate.

This characteristic is reflected in the logarithmic formulation of the equation. The curve is common to all the relationships in this study.

The diagram (Figure 3) showing the relationship of overall population density to population, and the correlation revealed by regression analysis ($r = 0.70$) indicates a significant connection between population density and population. The relationship, obviously, is not nearly as strong as that observed in Figure 2.

(Continued on page 22)

Figure 4

Relationship of RESIDENTIAL AREA TO POPULATION

(Logarithmic Scales)

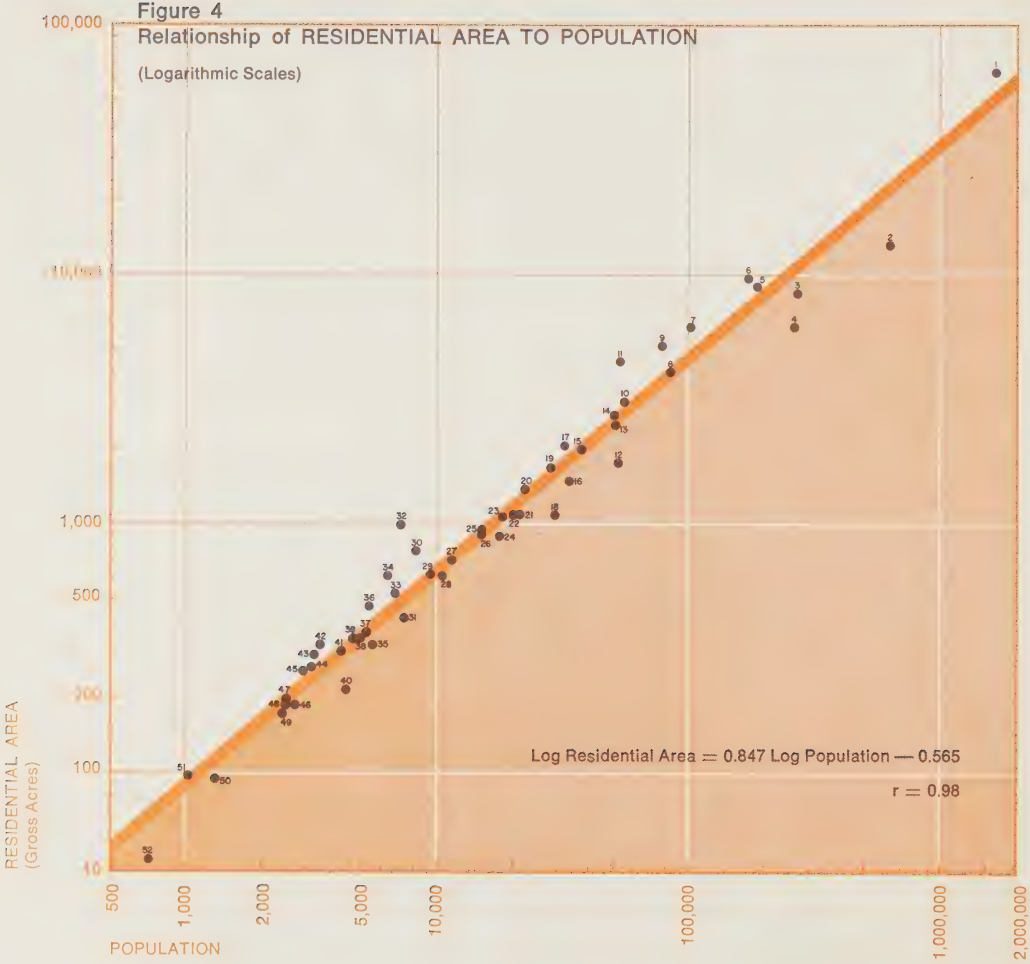


Figure 5
Relationship of GROSS RESIDENTIAL DENSITY TO POPULATION
(Logarithmic Scales)

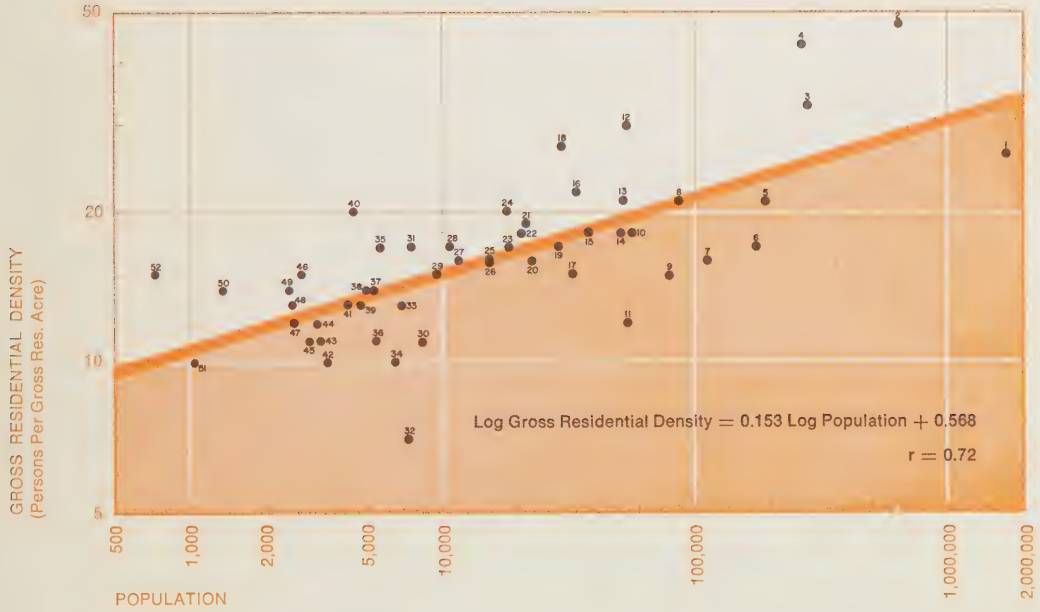


Figure 6
Relationship of COMMERCIAL AREA TO POPULATION

(Logarithmic Scales)

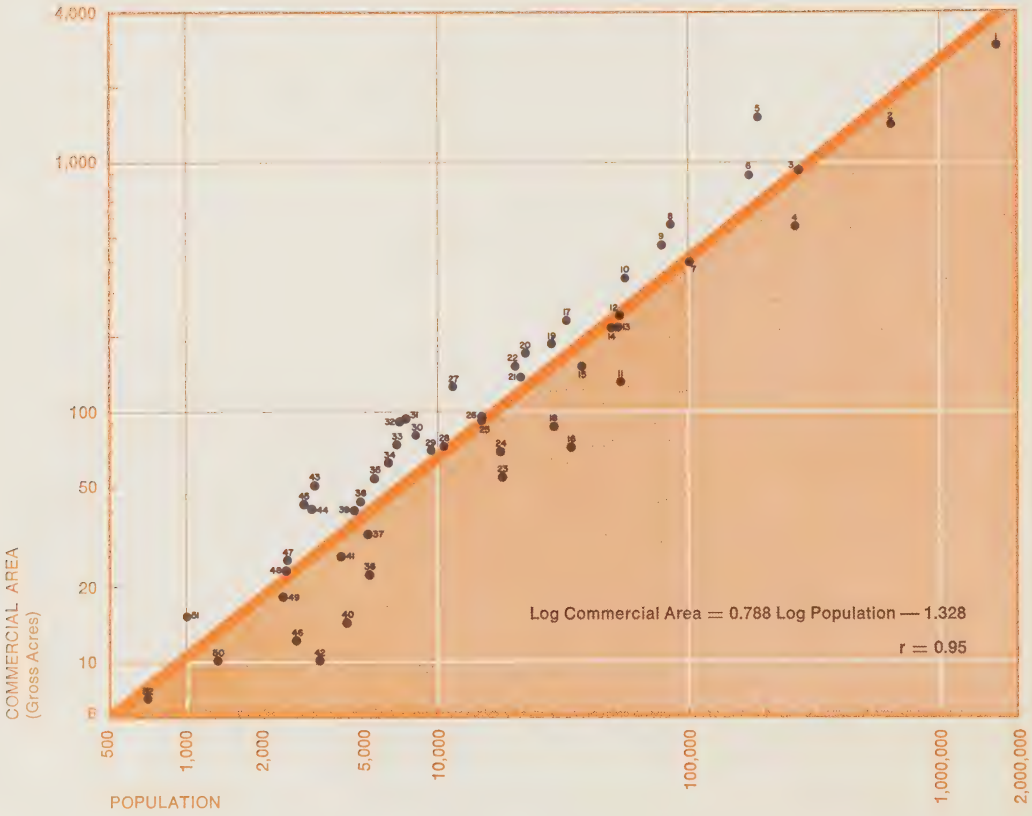
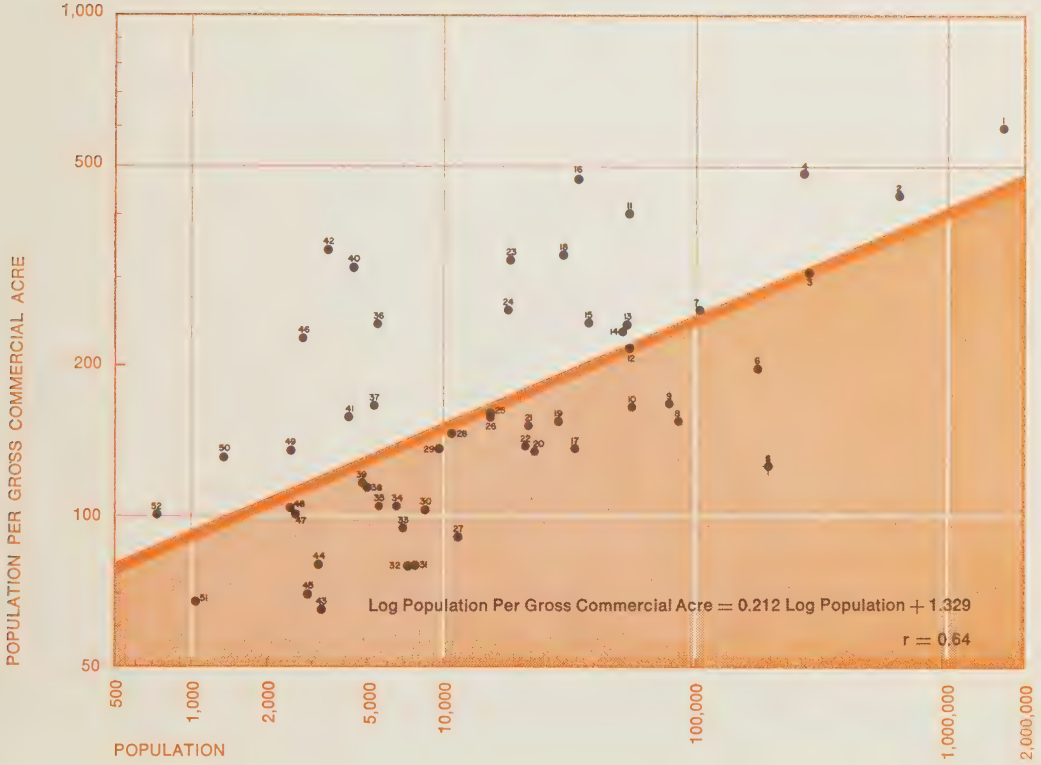


Figure 7
Relationship of POPULATION PER GROSS COMMERCIAL ACRE TO POPULATION
(Logarithmic Scales)



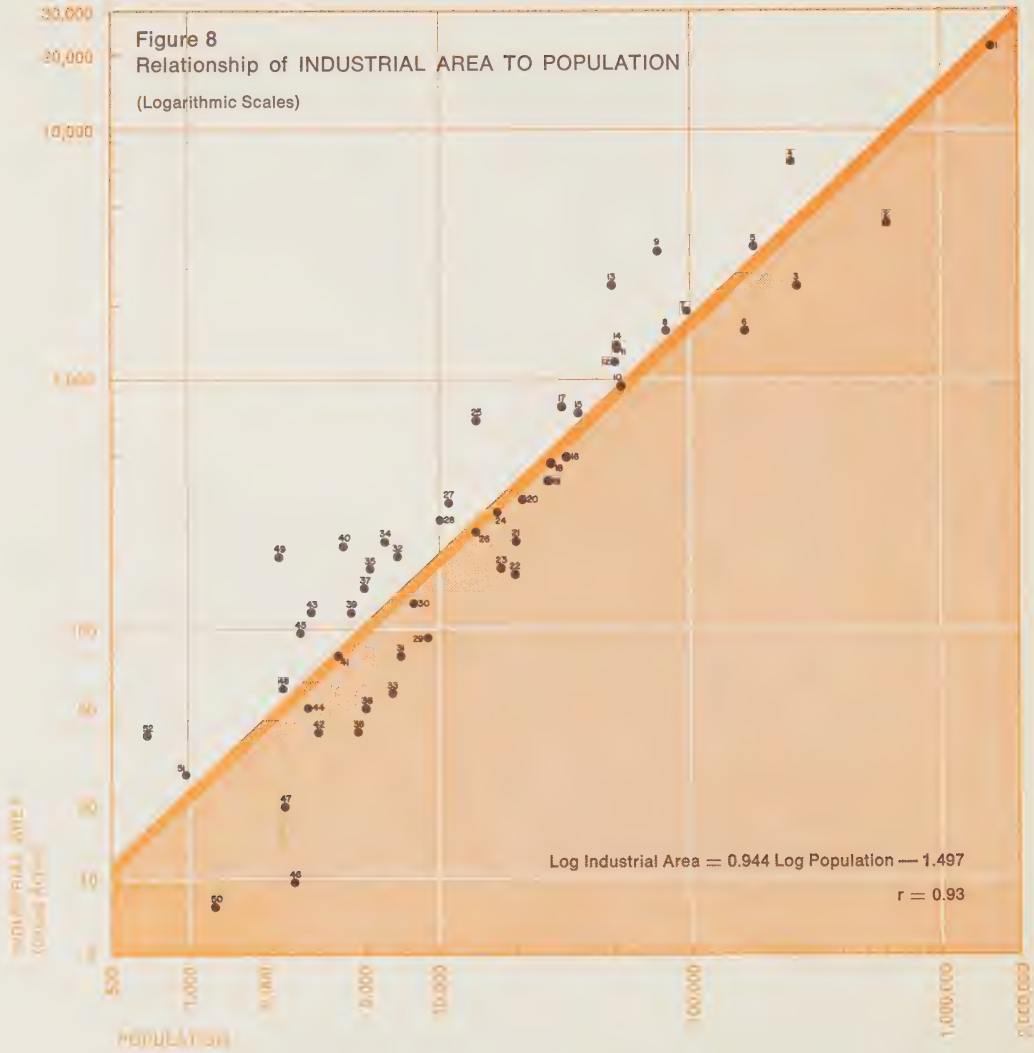
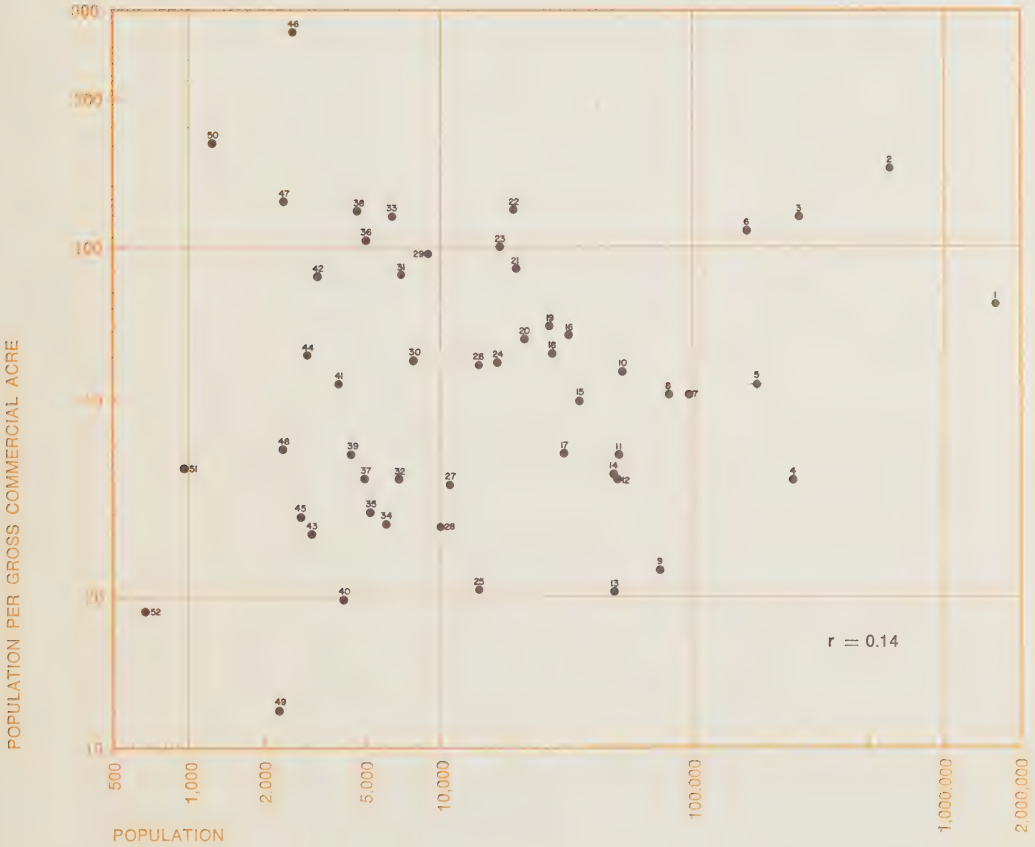


Figure 8
Relationship of INDUSTRIAL AREA TO POPULATION
(Logarithmic Scales)
Log Industrial Area = 0.944 Log Population — 1.497
r = 0.93
POPULATION

Figure 9
Relationship of POPULATION PER GROSS INDUSTRIAL ACRE TO POPULATION

(Logarithmic Scales)



This is the general pattern throughout the diagrams. For example, industrial area and population (Figure 8) are highly related ($r = 0.93$), whereas industrial intensity and population (Figure 9) are not related at all ($r = 0.14$).

The regression lines for the intensity relationships (as described by the logarithmic equations) are declining growth curves. The decline is sharper in the intensity relationships than in the area relationships.

The area relationships have been integrated in Section 4 to develop a model of land use areas.

VARIATIONS IN PATTERNS

The table of Land Use Variation (Figure 10) gives the positions of the urban municipalities in relation to the regression line for each of the land use categories. The columns indicate area values that are "Above" or "Below" the line.*

The table provides a simplified means of comparing land areas in the municipalities. In effect, it summarizes the diagrams which specify more exact values for the positions of the municipalities.

Since the intensity diagrams are derived from the same data as the area diagrams, centres having high values for developed area will have correspondingly low values for population intensity.

For example, Ingersoll (no. 32) is located above the regression line in Figure 2, and below the regression line in Figure 3. Consequently, the table is applicable to the intensity patterns when "Below" is substituted for "Above" and *vice versa*.

Municipalities with significant variations "○" from the regression lines can now be examined to identify those components which appear to contribute most to land use variation.

*Regression analysis provides a measure, termed the standard error of estimate, which indicates the amount of dispersion around the regression line. Approximately sixty-eight percent of the observations fall within one standard error of estimate on either side of the regression line. In the table "●" denotes these observations, "○" denotes the observations outside this limit.

Total Developed Area

Variations in total developed area can generally be traced to variations in the component land use categories. Since the residential component predominates (over 50% of developed land in most urban municipalities), any significant variation in this use will have a greater effect on the total developed area than a significant commercial or industrial area variation.

However, there are municipalities whose variations in total developed area reflect the influence of other factors. Owen Sound and Barrie's land use areas are all relatively small. The reason would appear to be their location at the head of lake inlets where development has clustered close to the harbour facilities, and where lateral spread has been restricted by steep-walled valleys. The consequences are relatively higher overall population densities as shown in Figure 3. Hamilton is similar in that much of its growth took place on the narrow plain between the escarpment and the lake.

Residential

Ontario's older cities have maintained compact residential areas. The cities of Toronto, Ottawa, Hamilton and Kingston are four with relatively small residential areas (variations below the regression line in Figure 4) that have resulted in higher gross residential densities (Figure 5).

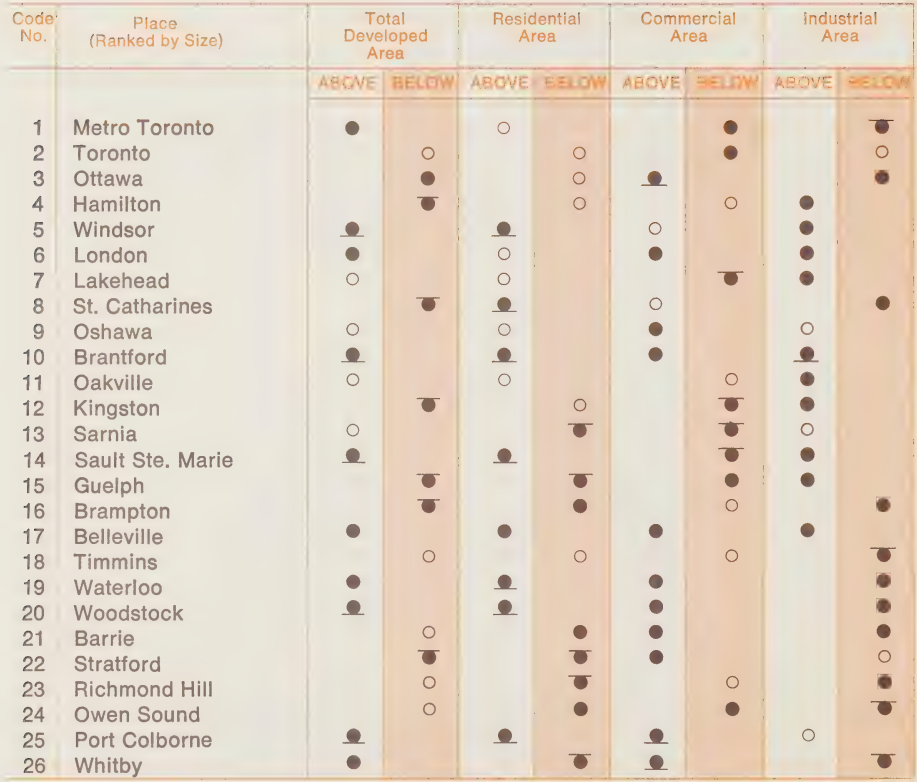
Other municipalities such as Oakville, Streetsville and Stouffville have relatively large residential areas (variations above the regression line in Figure 4) that are characteristic of many dormitory communities on the fringe of a metropolitan area.

Although intensity relationships do not have as high a correlation as area relationships, Figure 5 does indicate that gross residential density is generally higher in larger urban areas than in smaller places.

Figure 5 shows a residential density range of 10 to 15 persons per gross acre for most urban municipalities of less than 10,000 population; 15 to 25 for most of those between 10,000 and 200,000 population; and above 25 for the larger cities in the province.

Figure 10
SIMPLIFIED LAND USE VARIATION

(Observations in relation to regression lines in figures 2-9)



	ABOVE	BELOW
CLOSE (touching line in diagram)	●	●
INTERMEDIATE (within one standard error)	●	●
DISTANT (beyond one standard error)	○	○

Code No.	Place (Ranked by Size)	Total Developed Area		Residential Area		Commercial Area		Industrial Area	
		ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW	ABOVE	BELOW
27	Lindsay	●			●	○		●	
28	Cobourg	●			●	●		●	
29	Georgetown		○	●		●			○
30	Port Hope	○		○		●			●
31	Bowmanville		●		●	○			●
32	Ingersoll	○		○		○		●	
33	Markham	●		●		●			○
34	Dryden	○		○		●		●	
35	Espanola	●			●	●		●	
36	Streetsville		●	●			○		○
37	Dunnville		●		●		●	●	
38	Picton		○		●	●			○
39	Aylmer		●	●		●		●	
40	Acton		●		○		○	○	
41	Walkerton		●	●			●		●
42	Stouffville		●	●			○		●
43	Gravenhurst	○		●		○		●	
44	Kingsville		●	●		●			●
45	Kincardine	●		●		○		●	
46	Caledonia		○		●		○		○
47	Beamsville		●	●		●			○
48	Woodbridge	●			●	●		●	
49	Durham	○			●		●	○	
50	Shelburne		●		●		●		○
51	Cayuga	●		●		●		●	
52	Tottenham		●		○		●	○	

The increasing density is not surprising considering that single-family dwellings predominate in small urban municipalities, whereas multi-family dwellings, though not predominant, are common in larger urban areas.

Commercial

Two identifiable types of service communities appear as marked variations in Figure 6 — dormitory communities on the fringe of a metropolitan area and tourist-oriented communities in recreational areas.

Stouffville, Acton and Streetsville have relatively small commercial areas (variations below the regression line in Figure 6) because they are within the sphere of influence of a large urban centre (Toronto). Proximity of the large centre with its wide range and diversity of goods and services reduces the need for many commercial establishments that would ordinarily locate in the communities.

Tourist-oriented service centres such as Gravenhurst and Kincardine have relatively large commercial areas to serve the needs of cottagers and vacation visitors in and around the towns.

Industrial

Although there is a close relationship of industrial area to population (Figure 8, $r = 0.93$), it is not as close as the residential area and commercial area relationships. Variations above and below the regression line are greater and may be attributed to varying degrees of industrial development in urban municipalities.

For example, Hamilton, Oshawa, Sarnia and Port Colborne, with much of their economic base derived from manufacturing, have relatively large industrial areas. On the other hand, Ottawa and London with their large number of government and service-type activities have relatively small industrial areas.

The City of Toronto also falls below the regression line. Its industrial development is intense, characteristic of the pre-automobile era with multi-storey industrial buildings located near railway and streetcar routes. Much of the more recent industrial growth has occurred outside the city limits, yet within Metropolitan Toronto.

By combining these newer low-density industrial areas and the older high-density areas inside the city limits, the total industrial area of Metropolitan Toronto is very close to the regression line in Figure 8 — further evidence of the unity and indivisibility of the urban complex focussing on the City of Toronto.

Figure 9 shows that no relationship exists between industrial intensity and population. This may be attributed to the varying degrees of industrial development in urban municipalities and to the broad spectrum of manufacturing, wholesaling, transportation, utilities and other similar uses with widely varying land needs that might exist in any municipality.

FACTORS AFFECTING LAND USE

In summary, the diagrams suggest the impact of three major factors in the development of Ontario's urban municipalities. As generally recognized by planners and the literature of land use planning, these factors are:

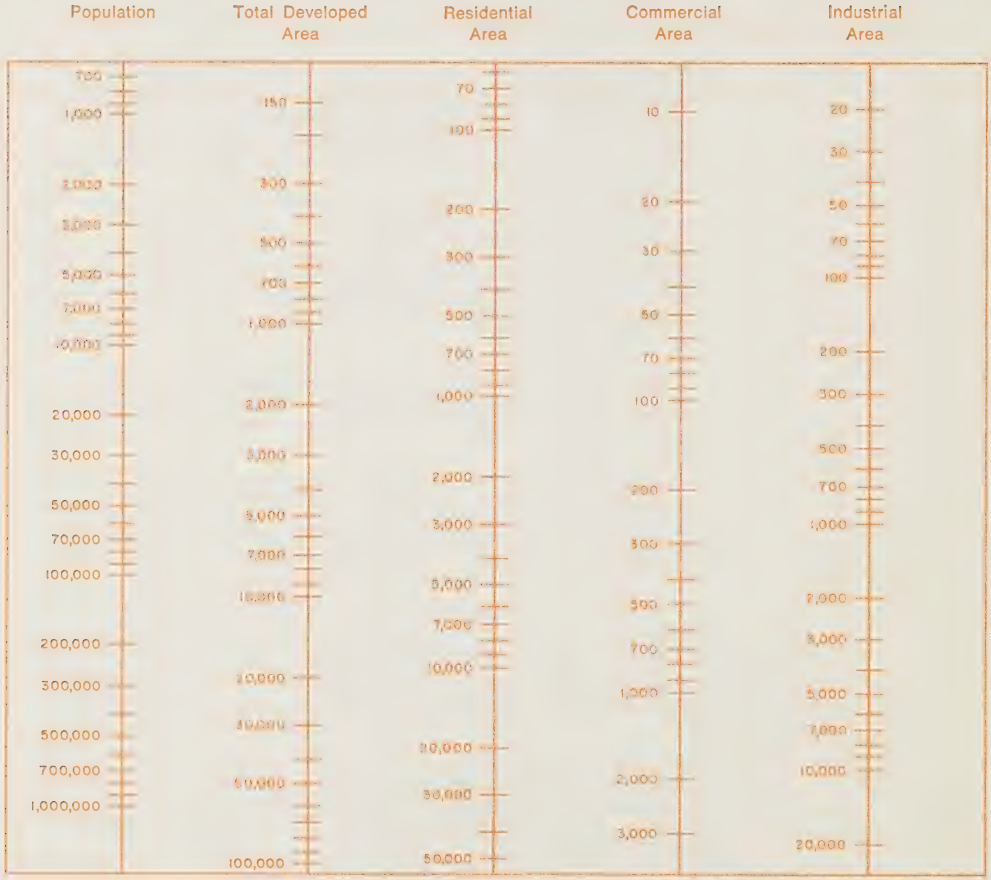
1. *The functional role* of a municipality is reflected in the types of economic activities engaged in by that municipality. In turn, each activity implants its peculiar space-consuming characteristics on the municipality.

2. *Physiographic control* — the confinements of geography — exerts some influence on the direction and extent of land consumed by the municipality. This factor was much more influential before the arrival of the automobile in the development of Ontario's older communities.

3. The automobile represents one of the products of *technological change* that has drastically altered the land consumption characteristics of the city. The advent of different transport technologies — from the horse and buggy to streetcar and automobile — has increased mobility within cities and, at the same time, expanded urban areas.

Technological change has also altered the design of industrial and commercial plants such that their space consumption characteristics have also changed — multi to single storey buildings, linear (along rail lines and arterial streets) to nuclear (industrial parks and shopping centers) groupings.

Figure 11
LAND USE AREAS* IN ONTARIO'S URBAN MUNICIPALITIES



*Areas in gross acres

4. MODEL OF LAND USE AREAS

The high degree of correlation between population and land use led to the formulation of a simple model* that incorporates the models for the separate relationships in the form of a chart (Figure 11).

The chart (a type of nomograph) was constructed from the regression lines as plotted on the *area-to-population* relationships.

It is used by placing a straight edge horizontally across the page and reading the gross acre values for total developed area, residential area, commercial area, and industrial area for any desired urban municipal population.

This model is an abstraction of reality. The degree to which it approximates the actual pattern of land use areas is gauged from the diagrams of each of the relationships. Obviously, it describes more accurately the actual pattern for the relationship of residential area to population than with industrial area to population.

As a model, it both compares and reflects the urban land use areas as they appeared in Ontario in the early 1960's. It provides a static view: one frame from a continuously moving picture of urban growth and change, of shifting characteristics in space consumption. Thus, the period of time for which this model is applicable and adequate is limited and its use must be tempered by and weighed against the assumptions that planners make about the stability of the present patterns.

*For a concise discussion of the structure and validity of models see Ira S. Lowry, "A Short Course in Model Design", *Journal of the American Institute of Planners,* XXXI, 2 (May, 1965), pp. 158-66.

CONCLUSION

This study set out to test the hypothesis that the quantities and population intensities of land in residential, commercial and industrial uses are closely related to the populations of urban municipalities.

Regression analysis, employed to examine the relationships, confirms that there is a close relationship of land use areas to population. The relationship is not as close between intensity of use and population and statistically not significant for industrial intensity and population.

The report has indicated some of the factors that influence variations in land consumption, particularly the formidable shaping elements of community age, physical site and economic function.

While continuing research is needed in this area, the diagrams and the model in this study can be employed by the local planner for analysing the land requirements of his municipality. They place in his hands a useful tool which should be used side by side with other analytic devices needed to make planning decisions.

APPENDIX

URBAN MUNICIPALITIES IN SURVEY

CODE No.	URBAN MUNICIPALITY	POPULATION	DATA DATE
1	Metro Toronto	1,652,300	1963
2	Toronto	630,300	1963
3	Ottawa	276,800	1963
4	Hamilton	264,100	1961
5	Windsor	191,800	1967
6	London	171,100	1963
7	Lakehead	100,800	1967
8	St. Catharines	84,400	1961
9	Oshawa	77,100	1966
10	Brantford	55,200	1961
11	Oakville	53,000	1967
12	Kingston	52,900	1965
13	Sarnia	51,200	1963
14	Saulte Ste. Marie	50,300	1959
15	Guelph	37,100	1959
16	Brampton	33,700	1965
17	Belleville	32,000	1964
18	Timmins	29,000	1965
19	Waterloo	28,000	1965
20	Woodstock	22,200	1964
21	Barrie	20,900	1959
22	Stratford	20,200	1959
23	Richmond Hill	18,000	1963
24	Owen Sound	17,500	1959
25	Port Colborne	14,800	1961
26	Whitby	14,800	1965

URBAN MUNICIPALITIES IN SURVEY

CODE No.	URBAN MUNICIPALITY	POPULATION	DATA DATE
27	Lindsay	11,300	1962
28	Cobourg	10,400	1965
29	Georgetown	9,300	1959
30	Port Hope	8,100	1959
31	Bowmanville	7,300	1961
32	Ingersoll	7,100	1965
33	Markham	6,700	1965
34	Dryden	6,300	1965
35	Espanola	5,500	1965
36	Streetsville	5,300	1963
37	Dunnville	5,200	1961
38	Picton	4,900	1965
39	Aylmer	4,600	1961
40	Acton	4,300	1964
41	Walkerton	4,100	1964
42	Stouffville	3,400	1963
43	Gravenhurst	3,200	1961
44	Kingsville	3,100	1962
45	Kincardine	2,900	1964
46	Caledonia	2,700	1966
47	Beamsville	2,500	1961
48	Woodbridge	2,500	1966
49	Durham	2,400	1965
50	Shelburne	1,300	1961
51	Cayuga	1,000	1965
52	Tottenham	700	1957

Community Planning Branch/Ontario Department of Municipal Affairs/801 Bay Street, Toronto 5, Ontario

URBAN LAND USE in ONTARIO

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